DIRECT CONNECTED HYDRAULIC CYLINDER FOR CIVIL PROJECTS

- A NEW CONCEPT FOR HYDRAULIC DRIVES -

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Abstract

More and more electro-hydraulic drives use the concept of direct driven hydraulic cylinders and hydraulic motors. Also, the advent of micro-processor controls and the use of environmentally safe hydraulic fluids is enhancing the opportunities for hydraulic drives used in Civil Engineering applications.

Historically, i.e. since the turn of the century in the Americas, most drives for large civil structures have been mechanical. As an example, the Panama Canal, built around 1910, has all miter gates, culvert valves and cylindrical valves operated using mechanical drives (i.e. electric motor, set of gears, strut arm or ball screws, etc.).

Many projects completed under the supervision of the US Army Corps of Engineers and Bureaus of Reclamation in the 1920's had a pure mechanical drive system for gate operation. See Figure 1 for one such miter gate drive.

Slowly by the late 1950's and early 1960's, some mechanical drives were being partially replaced by electro-hydraulic drives. In some cases, the hydraulic cylinders or motors were directly connected to the gates but in most cases, they still had a sector gear in between the prime mover and the gate.

In the last approximate ten years, the US Army Corps of Engineers have taken a rather bold decision to quite often go with a direct connected drive, i.e. hydraulic power unit providing power to hydraulic actuator which in turn is directly connected to the steel gate. Calculations of the cylinder and gate geometry can be

done rather easily for the optimum technical solution considering the connection point, cylinder stroke and gate movement geometry.
Enclosed are examples of recent direct connected cylinder applications:

a) Panama Canal Commission (miter gate and culvert valves). Figure 2.
b) Miter gates at Lock # 27 on the Mississippi River (US Army Corps of Engineers in St. Louis). Figure 3
c) Tainter gate cylinders on the Winfield Lock & Dam (US Army Corps of Engineers, Huntington, WV). Figure 4

Just looking at these installations and comparing the mechanical to hydraulic drives, it is obvious that direct connected drives are simple and reliable. Redundancy, if needed, can be added rather easily. They require no additional maintenance.

In contrast, drives for all large gates in Europe have traditionally been hydraulic and, of course, direct connected. The drive systems work very reliably. These systems normally operate between 3000 to 4500 psi operating pressure, hereby reducing the cylinder size, pump flow rate, piping sizing, etc. Also, it increases the controllability of the hydraulic system.

Use of environmental friendly fluids and analog / digital electronic controls makes hydraulics the most preferred drive and control solution today.

Addendum: Comparison of mechanical and hydraulic drives.

Comparison of Mechanical and Hydraulic Drives

Power Transmission

Mechanical	Hydraulic
• Articulated chains, gear racks, joined racks, worm gears or leaf segments, used as lifting elements, are driven by an electrical motor. • Transmission element is a multi-stage gearbox working on a pinion - or rope drum.	• Hydraulic cylinder (or motors) used as a lifting element and are driven by pressurized oil, which is supplied by a hydraulic power unit. • Transmission element is hydraulic oil, which, in comparison to the mechanical transmission element is not subject to wear.

Comparison of Mechanical and Hydraulic Drives

Components

Mechanical	Hydraulic
• Major structural components such as lifting elements, gear boxes, frames, etc. are custom designed and specially built.	• Hydraulic drives consist of components, which are produced in large quantities. Spare parts are therefore available as an off the shelf product.
• Spare parts, are therefore difficult to obtain, have long delivery times and because of their uniqueness, are extremely expensive.	• Only some parts of a hydraulic cylinder which are related to the stroke are custom made. All other parts of cylinder and system are standard industrial components.

Comparison of Mechanical and Hydraulic Drives

Physical Layout

Mechanical	Hydraulic
• Lifting components and drive elements have to be close. No flexibility in the position of the mechanical elements. Deviations in the line of force and power trans-mission over gear distance is difficult to achieve and extremely expensive.	• Because the power transmission is achieved by pressurized oil, there is almost no limitation in distance between the lifting and drive element. This allows for possible savings in underground structures.

Comparison of Mechanical and Hydraulic Drives

Operating Features

Mechanical	Hydraulic
• Smooth starting and deceleration is difficult to achieve, is inaccurate and can only be achieved at great costs.	• Speed control as well as smooth starting and deceleration is easy to obtain because of the very simple, standard components (proportional valves, variable pumps).
• Overload protection is not accurate (slipping clutch).	• In contradiction to mechanical drives, overload protection / safety valves can be adjusted easily and accurately.

Comparison of Mechanical and Hydraulic Drives

Maintenance

Mechanical	Hydraulic
• The lifting components require constant maintenance and lubrication. • These lubricants may cause environmental pollution. • Wear on the lifting components influences the safety factors.	• In the hydraulic drive system the energy carrier, oil, acts as a lubricant / corrosion protector. • Maintenance normally would be limited to inspection. • It is common to use environmentally friendly hydraulic fluids.

Comparison of Mechanical and Hydraulic Drives

Special Features

Mechanical	Hydraulic
a) *Synchronization* • Synchronization can be done but is more involved and due to more external parts is susceptible to damage, etc.	a) *Synchronization* • Can be achieved rather easily by proportional hydraulic system and cylinder position feedback (CIMS).
b) *Underwater* • Typical mechanical system cannot be used under water.	b) *Underwater* • Cylinders can be partially or completely under water and even the drive station can be submerged. The system, however, must be designed accordingly. This has been done in the past.